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Subject ~~Assay of Fission Product Contamination in the Mud of the White Oak Drainage System~~

~~L. H. Weeks~~

By ~~K. Z. Morgan~~

To

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No. 2 of 8 copies, Series A

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5/9/45

SECRET

ASSAY OF FISSION PRODUCT CONTAMINATION IN THE MUD OF THE WHITE OAK DRAINAGE SYSTEM

Samples have been taken over the past year of the surface fission product contamination of the mud in the White Oak Creek drainage system from Clinton Laboratories, finding as high as 10^{-1} μc/gm of mud. It was desired to know the extent of this contamination; therefore, an assay of the mud for total activity, depth and area covered has now been made and is herewith presented.

White Oak Creek Drainage System.

The White Oak Creek Drainage System shown on the attached map starts at the Settling Pond where the overflow of this pond enters the White Oak Creek. From here it flows along the creek bed for a distance of about 1400 feet. The course of the stream has been changed at this point and a dike (upper dike) placed across the old stream bed to divert the stream into a flat meadow about 2000 ft. long. This meadow is now a marsh as shown on the map. Since the waters spread over a large area, a large amount of filtering and settling takes place here and the area is highly contaminated.

At the end of the marsh there is a small pond (intermetidate pond) of about 1.2 acres in area formed by the lower dike. The active mud washed down from the marsh and activity in the water has a chance to settle in this pond during normal flow periods.

Overflow of the intermediate pond enters the stream bed and continues to White Oak Lake about 2600 ft. away. The downstream part of the lake, south of the point where a row of trees are shown across the lake, has a very steep bank and most of the active area is covered by water at all times; however, the section north of the trees is a very flat valley and a large area of mud flats is exposed during present normal and low water periods. Previously the dam was held at a higher level and this section was covered with water.

The overflow of the lake flows under the road and at low water times follows the stream bed to the Clinch River (see detailed map). During the time the water is being held at high levels by the Watts Bar Dam, the area below the White Oak Dam is part of the Watts Bar reservoir and water covers the area indicated on the map. Low levels of activity were noted in this area.

A survey of the drainage system with a portable counter found that a larger part of the contamination was located in four areas, namely - the marsh, intermediate pond, White Oak Lake mud flats and White Oak Lake. The smallest of the four, the intermediate pond, was assayed first and was used in determining the procedures for the remaining three areas.

Stratification

Preliminary surveys of the depth of activity were made to facilitate in taking samples to the proper depth. This was carried out for both the intermediate pond and the lake by taking cores and sampling the cores at various depths. The results of the stratification of activity (attached) showed that the major portion of the activity in the intermediate pond was confined to the top 8" and that in the lake was in the upper 4", except in the channel. It is assumed that the activity found below 8" in the intermediate pond was due to contamination of the sample from the top portion of the core. Later similar samples were taken in the marsh section, finding contamination below 12" at some points. Points were found in the mud flats during sampling where the samples had to be taken 6" deep.

Area Survey

The contaminated area was determined to be within the visible high water mark and a stadia survey was made of the above four areas, plus the area below the dam spillway, which was slightly contaminated. The detail maps of these areas are attached. From these areas surveyed and a USC & GS map, a composite map of the drainage system was prepared.

Sampling

It was found that core samples could be mixed so that the stratification would be destroyed and the contamination evenly distributed throughout the mud. This is shown by the results on two mixed cores from which four samples were picked at random:

	Core #1	Core #2
Sample 1	4.4×10^{-4} c/gm	3.2×10^{-3} c/gm
" 2	3.2×10^{-4} "	3.3×10^{-3} "
" 3	3.7×10^{-4} "	3.7×10^{-3} "
" 4	3.7×10^{-4} "	3.2×10^{-3} "

A sampler with a 2" inside diameter was used in taking the cores of the mud. From the average curie content per gram, after mixing, and total weight of the core, the curie per core was determined. An average dry core weight was used for the intermediate pond assay but it was found more accurate and convenient to use individual weights of each core, due to the variation in the soil density and difficulty in measuring the length of core in the field. The dry weight of each core was determined from the wet weight and a water content computed for each core.

Sampling points were arranged to give a random distribution* and were located in the field with a transet and stadia rod. Sampling points are shown on the detail maps. Zero samples were taken from the bottom of each core to make sure that all the active strata was being sampled.

* Correct ion made for proximity of samples 1, 2, 3, 4, 7, and 8. (Lake)

The samples are designated as follows: M for marsh, P for pond, MF for mud flats of the lake, L for the lake bottom samples and S for the samples below the spillway.

Counting

From each mixed core two samples of from 2 to 5 grams were taken at random for counting. In addition to giving more accurate results, the two samples served as a check on the thoroughness of the mixing. These samples were then counted on the second shelf of a standard counter for which the geometry (about 4.5%) was known. From this count and a correction for self-absorption*, the curie content per gram was determined.

Due to the large number of samples taken, the counting was limited to ten minutes maximum per sample, even though the sample counted only a few counts per minute. For the more active samples, i.e. 1000 c/m, a total of approximately 10,000 counts was used in determining the length of counting.

Distribution of Contamination

The following distribution of fission product contamination was found in the mud of the White Oak Drainage System.

	Av. c/sq.ft.	Area sq.ft.	Total Activity-curies
Marsh	91.5	466,000	42.7
Intermediate Pond	87.6	52,300	4.6
White Oak Lake mud flats	22.0	680,000	14.9
White Oak Lake (south of trees across lake)	8.5	750,000	6.8
Area below Spillway	1.04	300,000	.3
		Total...	69.3

The depth of contamination is not greater than that shown for each sample on the tables attached.

Due to the continual washing by the stream, only a small amount of contamination is contained in the creek bed and therefore can be neglected in arriving at the above total. The activity deposited on the banks of the creek and meadows between the intermediate pond and the lake was estimated to be not more than .1 curie and was considered negligible in comparison with the other areas.

An examination of the individual sample results finds wide variations but it is believed that each can be explained when compared to the terrain. Two samples of the above are points 6, 7, and 8 in the marsh section, and points L-9 and L-14. The high reading of 7 and 8 are due to the mud settling in this point when the water is held above the dike, while point 6 is in the stream where continual washing takes place. The latter case where a marked drop is noted in 4 lake samples is caused by the agitation of the water by a stream entering at this point.

Although there are wide variations of individual samples, especially in the marsh section, it is believed by the writer that the average of these random samples gives a fair average ofthe total contamination present. Averages of samples in a given cross-section of the areas show very consistent results.

*Report "Correction Factor for Self-Absorption in Mud Sampling", J. S. Cheka to K. Z. Morgan 1/27/45.

[redacted]

References

Area Survey: See Secret Note Books CLA-235 and CL-415
Sampling Points: See Secret Note Book CL-415
Counting of Samples: See Secret Note Book CL-415
Computation of μc/sq.ft.: See Secret Note Book CL-415

L. H. Weeks

LHW/r

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STRATIFICATION

SECRET

INTERMEDIATE POND

Distance from top of core (in)	Sample No. - μc/gm				
	1	2	3	4	5
0	4.10×10^{-3}	4.41×10^{-3}	2.73×10^{-2}	1.08×10^{-2}	7.63×10^{-3}
1	3.19×10^{-2}	3.50×10^{-2}	3.90×10^{-4}	6.53×10^{-2}	5.84×10^{-3}
2	7.59×10^{-3}	8.89×10^{-3}	0	1.93×10^{-2}	9.36×10^{-3}
4	6.98×10^{-3}	0	1.78×10^{-4}	8.52×10^{-3}	0
6	2.09×10^{-4}	0	0	2.66×10^{-4}	0
8.	0	0		0	2.68×10^{-4}
9.5				5.26×10^{-4}	
10	0				
12	1.28×10^{-4}				
14	0				
16	0				

Sample	Approximate Location
1	Southeast corner - between baffles
2	Southeast corner - on baffles
3	90' north of sample #2
4	Northeast corner
5	Southeast corner

LAKE SAMPLES

Distance from top of core (in.)	Sample No. - μc/gm					
	1	2	3	4	5	6
0	4.81×10^{-3}	4.93×10^{-3}	1.1×10^{-2}	1.35×10^{-3}	1.03×10^{-2}	1.20×10^{-2}
2.0		5.66×10^{-3}	0	0	1.84×10^{-3}	1.43×10^{-2}
3.0	2.66×10^{-3}					
4.0		0	0	0	0	0
5.5			0			
6.0			0		0	0
6.5	2.94×10^{-3}					
8.0	1.55×10^{-3}	0				
9.3	1.23×10^{-3}					
10.25	3.04×10^{-3}					
11.0	3.28×10^{-3}					

Sample	Approximate Location
1	About L-7 in channel
2	About L-12
3	About L-22
4	About L-28
5	Between L34 and L38
6	About MF-23

MARSH SAMPLES

Sample	Approx. Depth	c/sq.ft.	Cross-section Average
M-1		43.8	112.5
M-2		181.1	
M-3		28.3	
M-4		15.0	127.3
M-5	9 & 12"	338.7*	
M-6	4½"	1.7	
M-7	12"	393.0	219.6
M-8	9"	264.0	
M-9		96.7	
M-10	7"	19.9	58.3
M-11	9"	302.0	170.6
M-12	5½"	39.2	
M-13	9"	37.1	61.4
M-14	6½"	85.7	
M-15	6½"	149.0	
M-16	10"	124.7	98.9
M-17	4½"	23.2	
M-18		141.6	
M-19	9½"	140.3	102.3
M-20	6½"	25.1	
M-21	6½"	1.9	
M-22	12"2	323.6	210.4
M-23	6½"	5.7	

Sample	Approx. Depth	c/sq.ft.	Cross-section Average
M-24	5"	16.8	
M-25	8½"	307.0	104.8
M-26	4"	5.3	
M-27	7½"	16.1	
M-28	8"	356.6	195.7
M-29	7"	387.0	
M-30	8½"	23.1	
M-31	8½"	141.6	
M-32	6"	43.2	48.5
M-33	6½"	8.6	
M-34	4"	.8	
M-35	7½"	28.1	
M-36	7½"	23.0	20.2
M-37	7"	28.7	
M-38	4"	1.0	
M-39	8½"	15.6	
M-40	7"	114.6	33.2
M-41	5½"	1.7	
M-42	6"	1.0	
M-43	8½"	1.0	
M-44		6.9	

Av. 91.5 c/sq.ft
Area 466,000 sq.ft.
Total curies = 42.7

*Ave. of two samples

INTERMEDIATE POND SAMPLES

Sample	Av. μc/gm
P-1	9.7×10^{-3}
P-2	4.28×10^{-3}
P-3	1.24×10^{-2}
P-4	5.07×10^{-3}
P-5	9.75×10^{-3}
P-6	4.91×10^{-3}
P-7	7.31×10^{-3}
P-8	1.02×10^{-2}
P-9	4.35×10^{-2}
P-10q	4.57×10^{-3}

Av. 7.2×10^{-3}
Av. Wt. 265 gm.
Av. Activity/core = 1.91 μc
Av. Activity/sq.ft. = 87.4 μc
Area - 52,600 sq.ft.
Total curies = 4.6

WHITE OAK LAKE MUD FLATS

Sample	Approx. Depth	μc/sq.ft.	Cross-section Average
MF-1	6"	81.1	
MF-2	6"	24.2	41.4
MF-3	4"	18.9	
MF-4	3½"	15.4	
MF-5	4"	34.2	23.2
MF-6	6"	20.0	
MF-7	6"	5.5	
MF-8	6"	7.2	22.2
MF-9	4"	54.0	
MF-10	2"	11.4	
MF-11	4"	30.5	19.6
MF-12	4"	16.9	
MF-13	6"	12.8	
MF-14	5½"	15.9	20.3
MF-15	6"	35.3	
MF-16	6"	7.1	
MF-17	6"	11.2	19.6
MF-18	6½"	13.2	
MF-19	6"	46.8	
MF-20		5.4	
MF-21		4.7	
MF-23	5"	5.4	11.7
MF-22	6¼	19.4	
MF-24	6"	23.8	
MF-25		16.2	
MF-26		34.8	
MF-27	4"	32.2	

Av. 21.98 μc/sq.ft.
Area - 680,000 sq.ft.
Total curies = 14.9

SECRET

WHITE OAK LAKE

Sample	Approx. Depth	μc/sq.ft.	Cross-section Average
L-1	4"	5.8	
L-2	4"	1.9	
L-3	3"	9.9	
L-4	4"	8.4	
L-5	4"	9.7	
L-6	4"	8.5	
L-7		0.6	
L-8		1.9	
L-9		10.0	
L-10	4"	4.6	
L-11	4"	4.3	4.0
L-12		4.0	
L-13		3.2	
L-14	5"	8.6	
L-15	5"	16.4	14.4
L-16		18.3	
L-17	4"	4.1	
L-18	5"	10.0	7.8
L-19	5"	8.5	
L-20	5½"	12.4	
L-21	5"	3.9	11.9
L-22	5½"	19.9	
L-23		11.6	
L-24	4"	8.9	
L-25	3"	4.9	5.7
L-26	5"	3.3	
L-27	4½"	8.5	
L-28	5"	8.9	8.4
L-29	3"	7.8	
L-30	5"	11.8	
L-31	5"	9.8	9.9
L-32	5"	11.1	
L-33	3"	7.0	
L-34	5"	3.6	
L-35	5"	3.7	
L-36	5"	16.8	11.4
L-37	3½"	10.2	
L-38	4"	11.9	
L-39	4"	5.6	
L-40	5"	1.9	
L-41	4"	15.4	

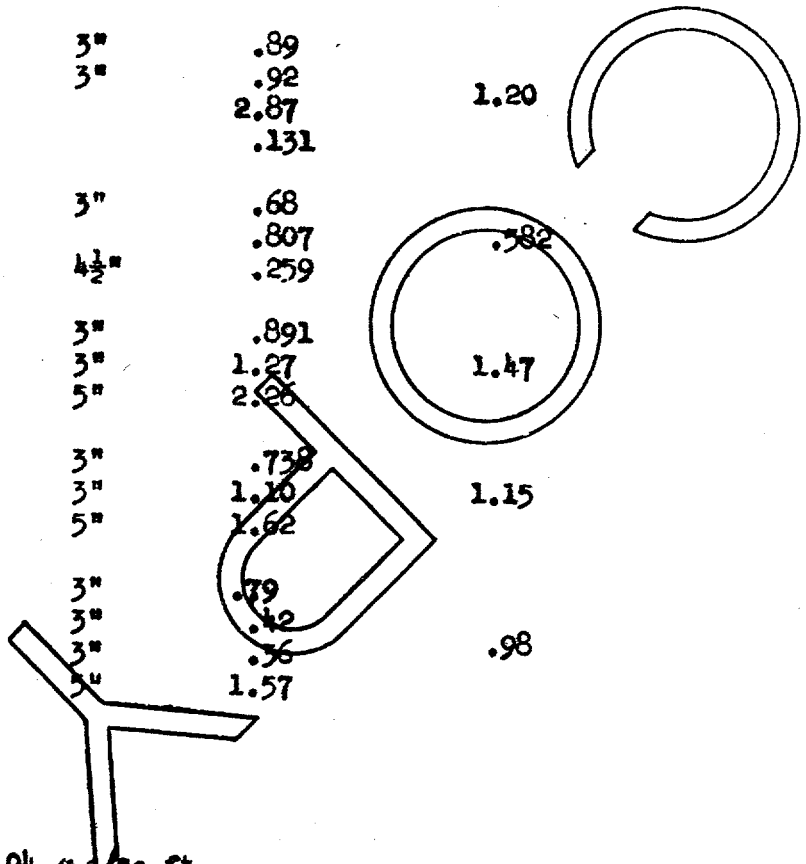
Av. 8.5 μc/sq.ft.
Area 79,5000 sq. ft.
Total 6.8 curies

SECRET

AREA BELOW SPILLWAY SAMPLES

Sample	Approx. Depth	μc/sq.ft.	Cross-Section Average
S-1	3"	.215	.215
S-2	3"	0	.261
S-3		.523	
S-4	3"	2.06	
S-5	3"	3.06	1.83
S-6	5"	.383	
S-7	3"	.89	
S-8	3"	.92	
S-9		2.87	1.20
S-10		.131	
S-11	3"	.68	
S-12		.807	.582
S-13	4½"	.259	
S-14	3"	.891	
S-15	3"	1.27	1.47
S-16	5"	2.26	
S-17	3"	.738	
S-18	3"	1.10	1.15
S-19	5"	1.62	
S-20	3"	.79	
S-21	3"	.42	
S-22	3"	.56	.98
S-23	5"	1.57	

Av. - 1.04 μc/sq.ft.
Area 300,000 sq. ft.
Total curies = .3



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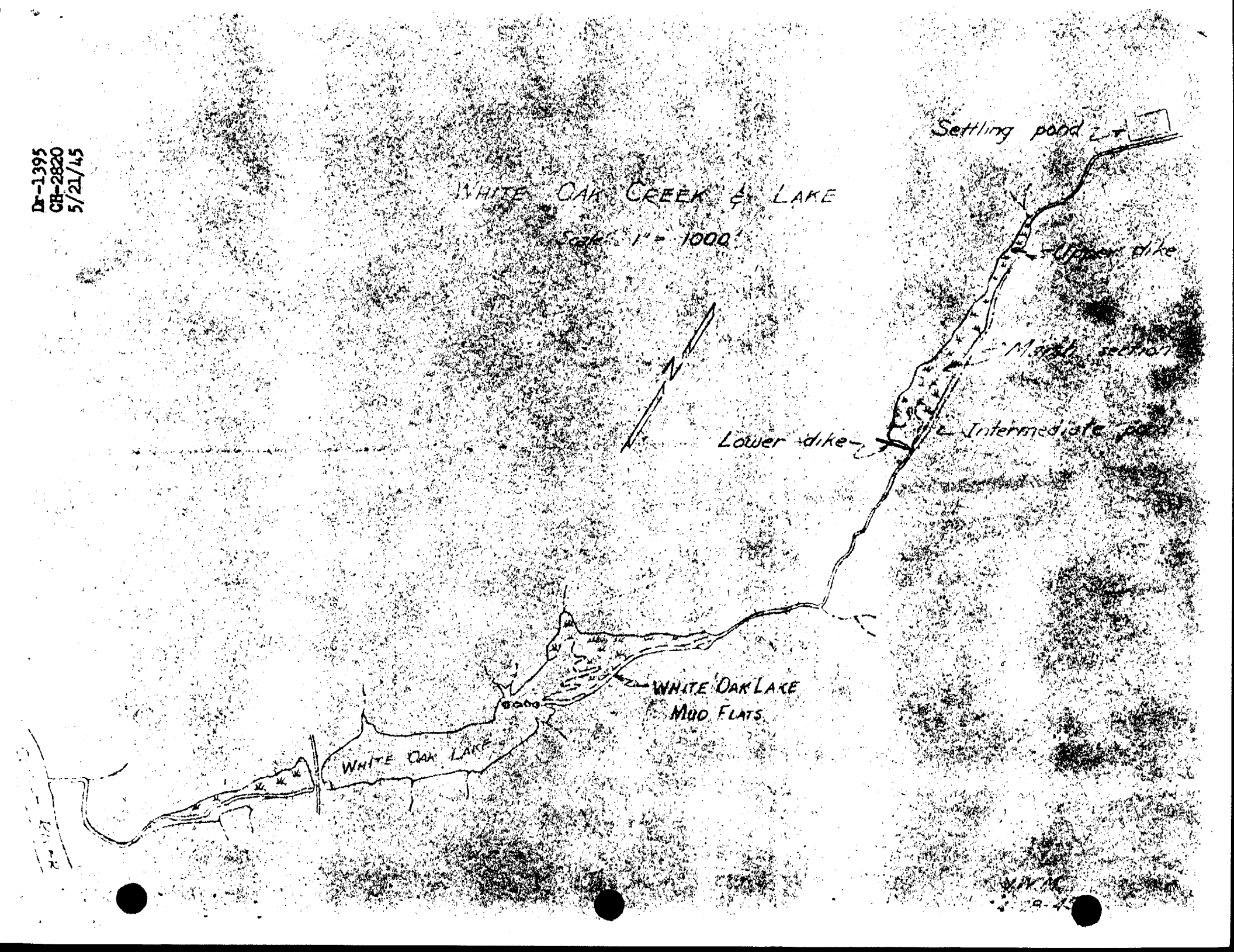
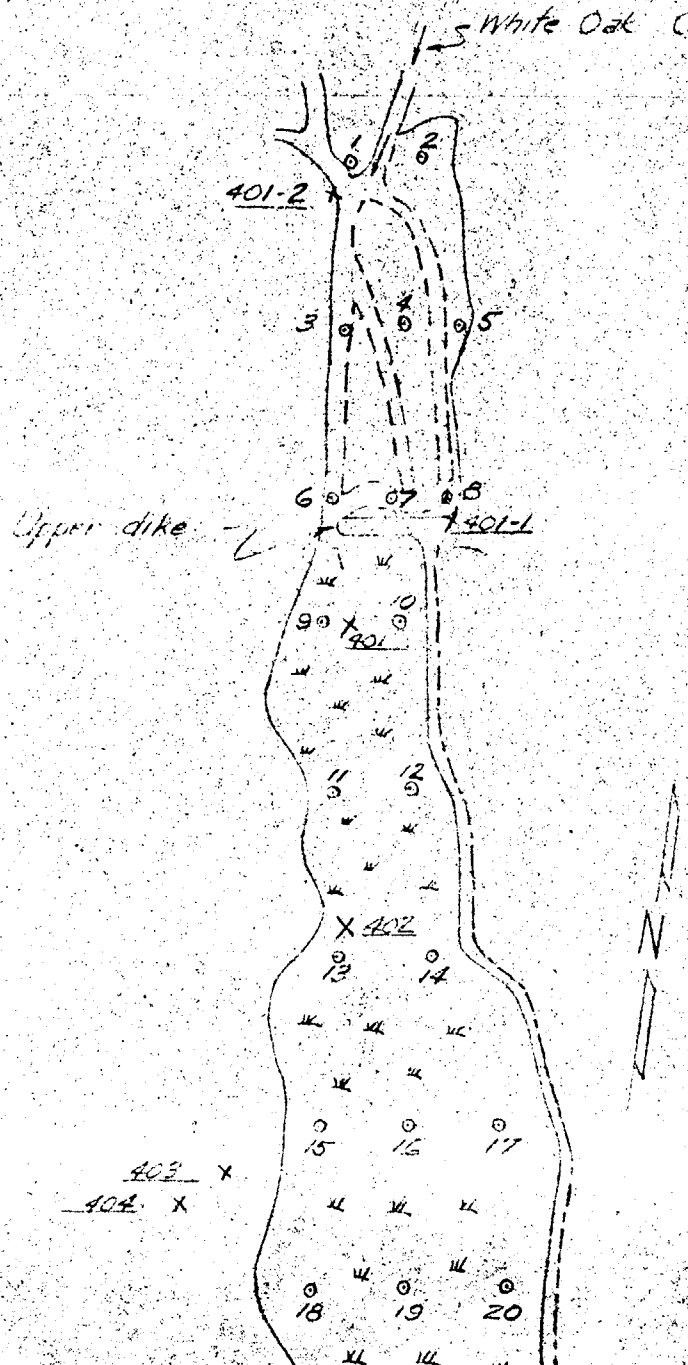
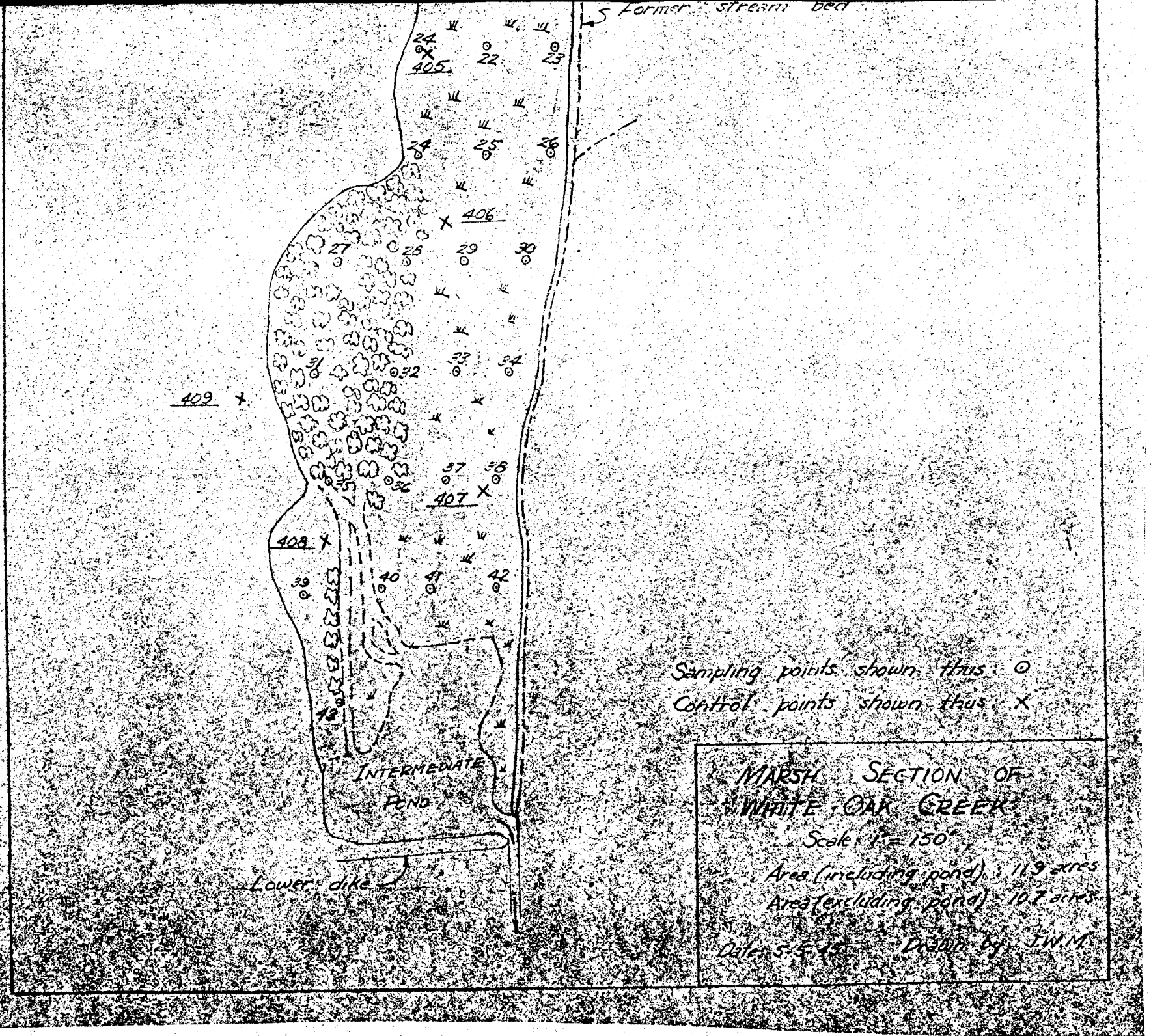
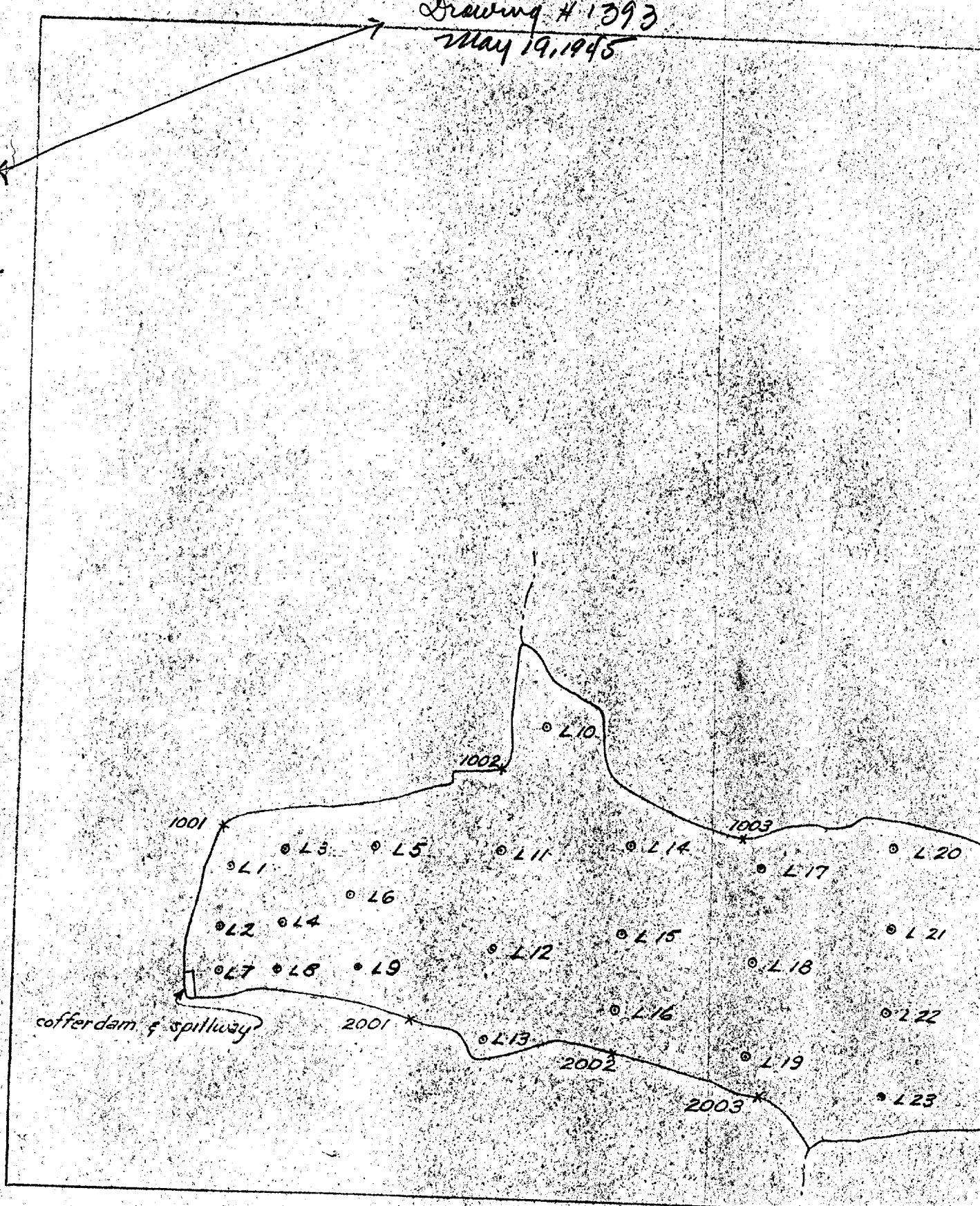


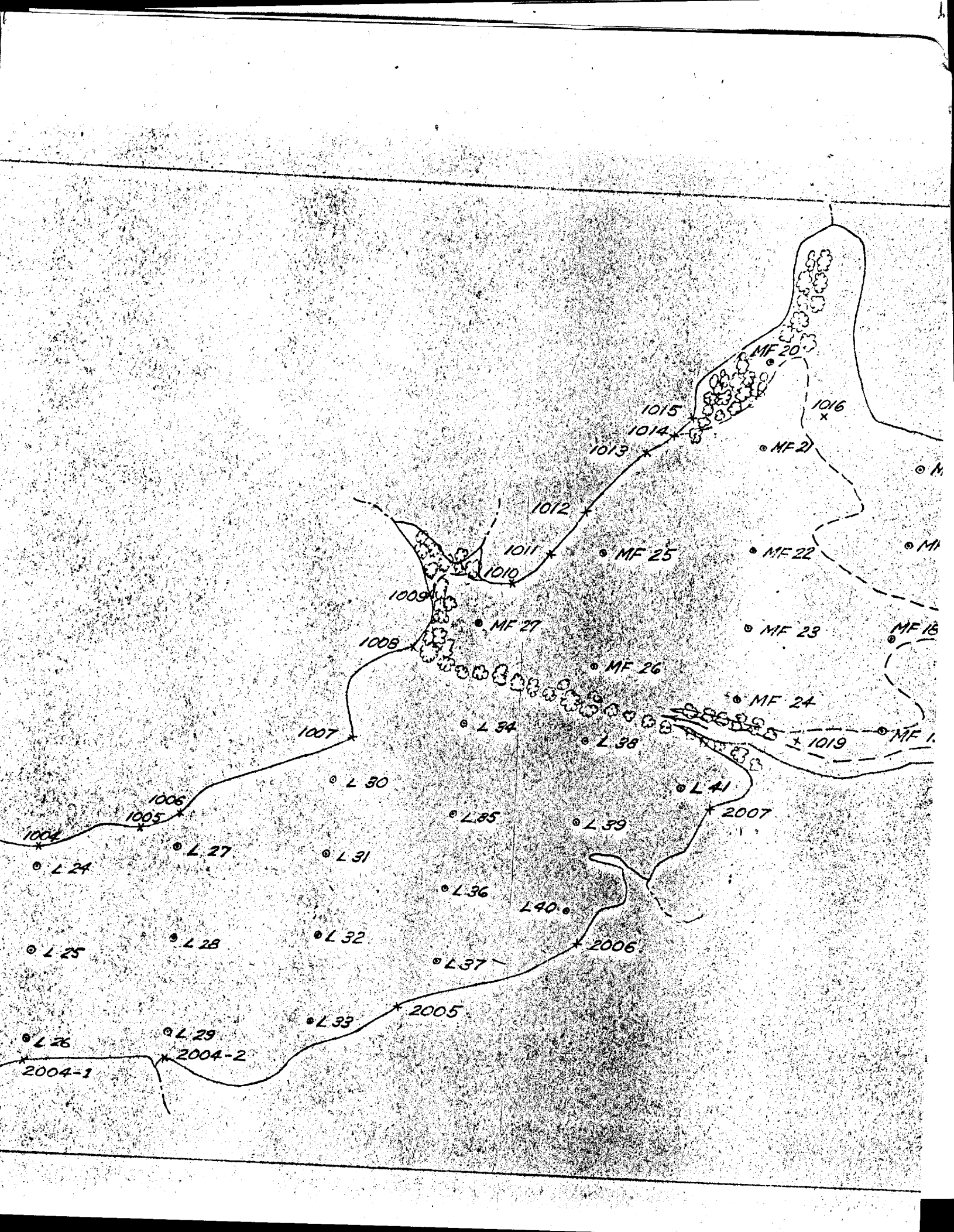
Drawing #1391
May 19, 1945




Former stream bed
405
406
407
408
409
Intermediate Pond
Lower dike
Sampling points shown thus: ⊙
Control points shown thus: X
MARSH SECTION OF WHITE OAK CREEK
Scale 1" = 150'
Area (including pond) 11.9 acres
Area (excluding pond) 10.7 acres
Date 5-5-43 Drawn by J.W.M.

Drawing #1393
May 19, 1945

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1006
1005
L 35
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2007
1004
L 27
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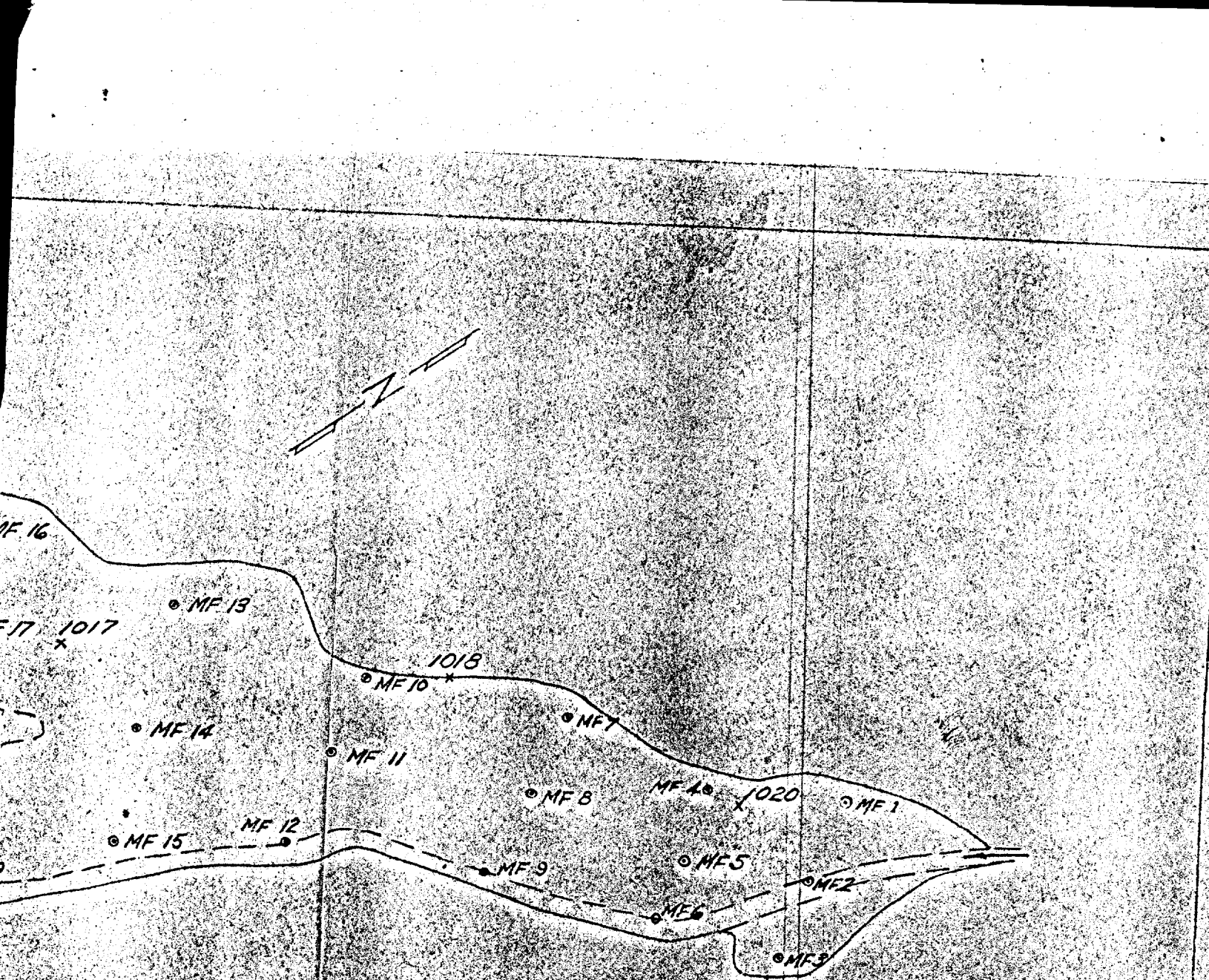
2004-2
2004-1



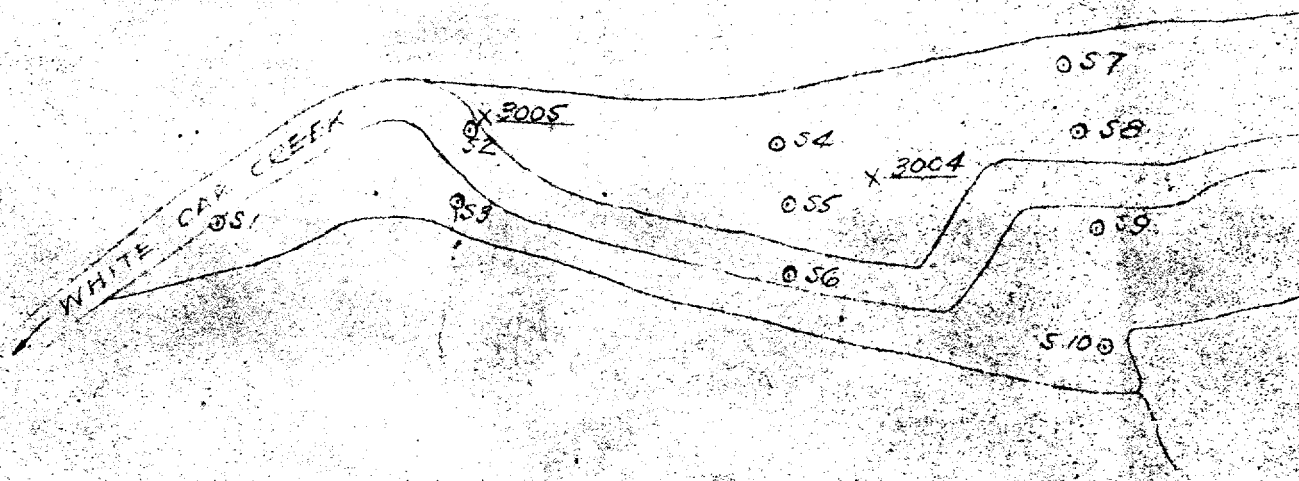
Note: Sampling points shown thus ⊙
Control points shown thus ×

WHITE OAK LAKE & MUD FLATS

Scale: 1" = 150'

Area: 35.9 acres

Date: 4-20-45 Drawn by: J.W. Minter


WHITE CAP CREEK
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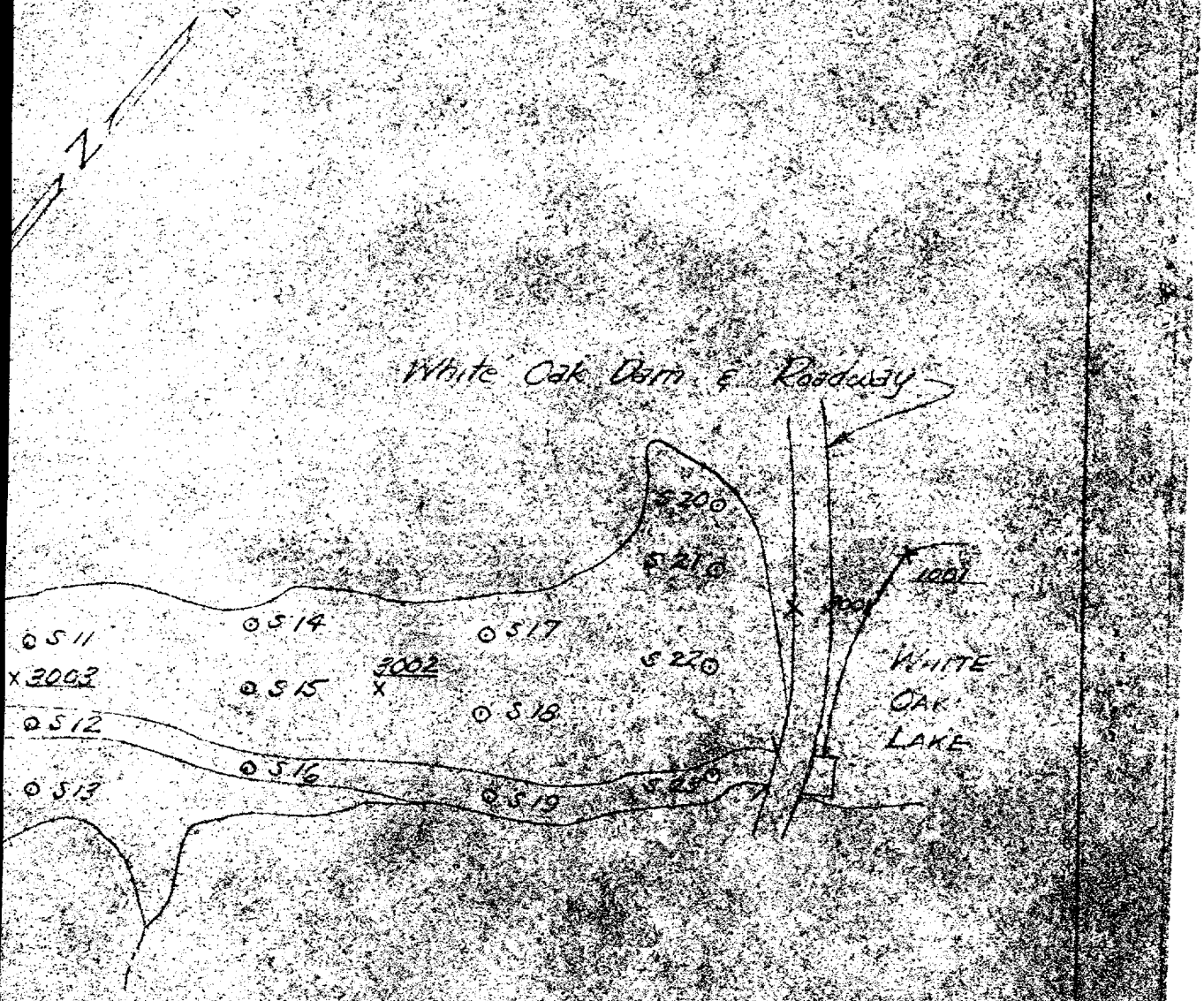
59
510
3005
3004



Sampling points shown thus ⊙
Control points shown thus X

WHITE OAK DAM SPILLWAY AND WATTS BAR DAM BACKWATER SECTION

Scale 1" = 150'

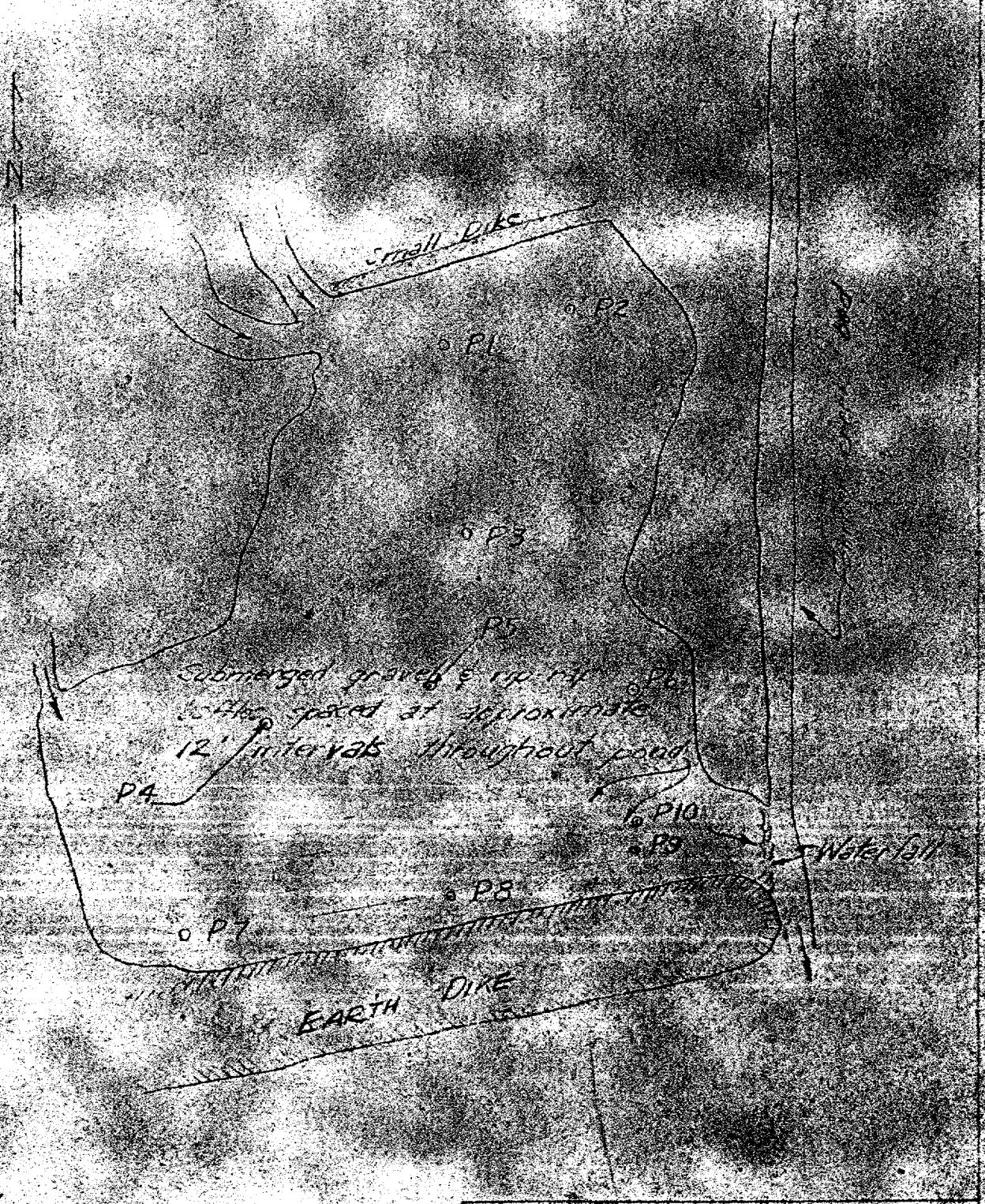
Area 6.9 acres

Date 5 5 45

Drawn by J.M.M

Tennessee Valley Authority

Drawing #1390
May 19, 1945



INTERMEDIATE POND

Scale: 1"=20' Area = 1.2 acres

Date: 5-5-45 Drawn by J.H.N.